

American College of Radiology
ACR Appropriateness Criteria®
Radiologic Management of Infected Fluid Collections

Variant: 1 Patient with right lower quadrant abdominal pain, fever, and leukocytosis for 7 days. Physical examination shows no peritoneal signs. CT scan shows a thin-walled fluid collection, greater than 3 cm, adjacent to the cecum, nonvisualization of the appendix, and an appendicolith. Imaging findings are highly suspicious for appendicitis. Treatment includes antibiotics.

Procedure	Appropriateness Category
Percutaneous catheter drainage only	Usually Appropriate
Percutaneous catheter drainage followed by delayed surgery	Usually Appropriate
Needle aspiration	May Be Appropriate
Surgical drainage	May Be Appropriate
Conservative management only	Usually Not Appropriate

Variant: 2 Patient with a history of left hemicolectomy 2 months ago for colon carcinoma. Two weeks after placement of a drain into an abdominal abscess; the patient presents with abdominal pain and fever. Drain output is 25 cc per day and the collection is unchanged in size by CT. Treatment includes antibiotics.

Procedure	Appropriateness Category
Catheter upsizing	Usually Appropriate
Intracavitary thrombolytic therapy and drainage	Usually Appropriate
Laparoscopic drainage	May Be Appropriate
Open surgical drainage	May Be Appropriate
Continued antibiotics and drainage (no change in care)	May Be Appropriate
Continued antibiotics and drain removal	Usually Not Appropriate

Variant: 3 Patient who is an intravenous drug abuser presents with fever and tachycardia and on imaging is found to have 2 noncommunicating splenic abscesses accessible percutaneously through a 1 cm rim of normal splenic tissue. Treatment includes antibiotics.

Procedure	Appropriateness Category
Percutaneous catheter drainage only	Usually Appropriate
Splenectomy	Usually Appropriate
Needle aspiration	May Be Appropriate
Conservative management only	Usually Not Appropriate

Variant: 4 Patient with abdominal pain radiating to the back 5 weeks after hospitalization for acute pancreatitis. Afebrile. CT scan shows a walled-off collection in the body of the pancreas indenting a broad portion of the body of the stomach, affecting the gastric outlet. The collection is percutaneously accessible with a 3-cm window. MR cholangiopancreatography shows a patent pancreatic duct.

Procedure	Appropriateness Category
Endoscopic cystgastrostomy	Usually Appropriate

Percutaneous catheter drainage only	May Be Appropriate
Surgical cystenterostomy	May Be Appropriate
Percutaneous needle aspiration	May Be Appropriate
Conservative management only	Usually Not Appropriate

Variant: 5 Patient with a 2 week history of cough, fever, and foul-smelling sputum. Worsening condition despite a full course of broad-spectrum antibiotics. Sputum cultures negative. CT scan shows a right lower lobe abscess. Treatment includes antibiotics.

Procedure	Appropriateness Category
Percutaneous catheter drainage only	May Be Appropriate
Surgery	May Be Appropriate
Another course of antibiotics and postural drainage	May Be Appropriate (Disagreement)
Needle aspiration	Usually Not Appropriate

Variant: 6 Patient with a 3 week history of pneumonia, fever, dyspnea. Worsening condition despite a full course of broad-spectrum antibiotics. CT scan shows a loculated pleural collection with overlying pleural thickening (empyema). Treatment includes antibiotics.

Procedure	Appropriateness Category
Percutaneous catheter drainage with administration of thrombolytic therapy	Usually Appropriate
Video-assisted thoracic surgery decortication	Usually Appropriate
Open decortication	May Be Appropriate
Needle aspiration	Usually Not Appropriate
Another course of antibiotics and postural drainage	Usually Not Appropriate

Variant: 7 Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian abscess (TOA) greater than 3 cm. Treatment includes antibiotics.

Procedure	Appropriateness Category
Transabdominal percutaneous catheter drainage	Usually Appropriate
Transgluteal percutaneous catheter drainage	Usually Appropriate
Transrectal percutaneous catheter drainage	Usually Appropriate
Transvaginal percutaneous catheter drainage	Usually Appropriate
Transabdominal needle aspiration	May Be Appropriate
Transgluteal needle aspiration	May Be Appropriate
Transrectal needle aspiration	May Be Appropriate
Transvaginal needle aspiration	May Be Appropriate
Conservative management only	May Be Appropriate
Endoscopic US-guided drainage	May Be Appropriate
Surgical/laparoscopic drainage	May Be Appropriate

Variant: 8 Patient with recent endoscopic retrograde cholangiopancreatography and sphincterotomy now with 3 weeks of worsening right upper quadrant pain, fever, jaundice, and malaise. CT scan reveals 2 liver abscesses greater than 3 cm. MRCP demonstrates no biliary obstruction or stones. Treatment includes antibiotics.

Procedure	Appropriateness Category
Percutaneous catheter drainage only	Usually Appropriate
Needle aspiration	May Be Appropriate
Percutaneous catheter drainage with conversion to percutaneous biliary drain	May Be Appropriate
Surgical management	May Be Appropriate
Continued conservative management	May Be Appropriate

Variant: 9 Patient presents to the emergency department with 5 days of progressive ankle swelling and 2 days of fever. An ultrasound was obtained given the diffuse soft-tissue swelling around the ankle which revealed a subperiosteal abscess. Treatment includes antibiotics.

Procedure	Appropriateness Category
Surgical drainage	Usually Appropriate
Needle aspiration	May Be Appropriate
Percutaneous catheter drainage only	May Be Appropriate
Continued conservative management	Usually Not Appropriate

Panel Members

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Summary of Literature Review

Introduction/Background

Radiologic management strategies are often preferred therapeutic options for infected fluid collections throughout the body [1]. The current literature demonstrates high clinical success rates with low complications, especially when compared with more invasive therapies, in particular open surgical drainage (OSD), which has high associated morbidity and mortality. However, physiologic and anatomic factors may render radiologic management less optimal compared with alternative therapies. Such factors include collections without a safe percutaneous approach, collections refractory to radiologic management, and collections with a more favorable endoscopic drainage option. In the past decade, endoscopic, laparoscopic, and multidisciplinary approaches have been described, and those approaches should be considered when applicable to reduce procedure risk, improve clinical success, avoid external catheter placement, and improve patient comfort.

Overview of Diagnostic Imaging Options

Detection and evaluation of fluid collections is typically accomplished with CT or ultrasound (US) in patients with signs and symptoms of infection. Routine imaging of postoperative patients should be discouraged because postoperative fluid collections are commonly present and may not be infected. US is fast and provides more detailed evaluation of the internal structure and composition of complex collections. US is more limited in the evaluation of collections deep within the soft tissues or adjacent to the loops of bowel than CT or MRI, and it fails to penetrate intracavitary, pulmonary, or enteric gas. Therefore, US is more

commonly used to screen for superficial or large fluid collections and collections within or adjacent to solid organs. CT provides the advantage of detecting deep collections, and the use of intravenous (IV) and oral contrast can help distinguish collections from adjacent vasculature or bowel. CT is usually the first-line modality in patients with fever of unknown origin. Multidetector CT scanners with sagittal and coronal reformatting can help distinguish collections from adjacent structures.

Overview of Therapeutic Options

The choice of imaging guidance for draining fluid collections varies with body habitus, presence of adjacent structures, size and location of the collection, and presence of intracavitary or enteric gas. The choice of treatment options for a given collection may vary among operators and depends on size, location, and clinical presentation. Options include antibiotics coupled with supportive measures such as bowel rest and hyperalimentation, needle aspiration for drainage or to hone antibiotic coverage, percutaneous catheter drainage (PCD), PCD with thrombolytic therapy, endoscopic drainage, immediate surgery, or delayed surgery.

Two basic techniques are available for PCD: the Seldinger technique and the trocar technique [2]. For percutaneous aspiration and drainage, success thresholds of 95% and 85% have been recommended [3]. Choice of technique is primarily operator preference, though the trocar technique has been advocated for endocavitary drain placement to avoid the risk of loss of access during the process of serial dilation, a complication associated with the Seldinger technique. Although a safe window to the collection is required for drainage, techniques such as hydrodissection [4,5] and alternative approaches such as transhepatic drainage of abdominal collections [6,7] have been described to improve technical success rates.

Discussion of Procedures by Variant

Variant 1: Patient with right lower quadrant abdominal pain, fever, and leukocytosis for 7 days. Physical examination shows no peritoneal signs. CT scan shows a thin-walled fluid collection, greater than 3 cm, adjacent to the cecum, nonvisualization of the appendix, and an appendicolith. Imaging findings are highly suspicious for appendicitis. Treatment includes antibiotics.

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A. Conservative management only

For the management of small (<3 cm) collections [2], most authors advocate a trial of antibiotics alone with consideration given to needle aspiration to hone antibiotic coverage for persistent cases [27,28]. This approach uses follow-up imaging and repeat aspiration if the collection does not resolve [2].

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B. Needle aspiration

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C. Percutaneous catheter drainage followed by delayed surgery

Some disagreement exists in the literature regarding the need for subsequent ("interval") appendectomy after successful PCD [16]. In a study of 1,012 patients with appendicitis, Kaminski et al [16] evaluated the need for PCD and the subsequent need for interval appendectomy after successful PCD. On initial presentation, the vast majority of patients with appendicitis underwent emergent surgery, although a strategy of avoidance of open surgery in both simple and complicated cases of appendicitis has continued to evolve since this publication. If nonoperative management was successful, 80% of patients were cured without surgery. The push for conservative management, including PCD, rather than acute appendectomy for patients with appendicitis complicated by abscess or phlegmon is supported by a meta-analysis of 1,572 patients in 17 studies showing significant reductions in complication rates [17]. Factors that were associated with receiving an interval appendectomy after antibiotics and PCD include recurrent appendicitis, age ≤ 13 , and treatment with antibiotics alone [18]. However, approximately 25% of patients with appendiceal abscess fail PCD and require operative intervention [19]. Risk factors for PCD failure in patients with appendiceal abscess include patient complexity, female gender, and earlier drainage [19]. Drainage failure is associated with longer hospital stays but no increase in patient mortality [19].

For mature abscesses associated with Crohn disease, an initial combination of PCD, antibiotics, high-dose steroids, bowel rest, and (on occasion) hyperalimentation has been advocated [20] to reduce the failure rate of PCD, temper the acute infection, and allow for surgical resection under more sterile, elective conditions [21]. When surgery is required, preliminary PCD has been shown to reduce postdrainage complications and the ultimate need for stomal creation [22]. Some patients (33%–50%) will ultimately require surgical drainage or resection [23,24], but most authors still advocate a first-line trial of PCD if technically possible. In a study of 25 patients with Crohn disease, PCD performed an average of 37 days before surgery significantly reduced the rate of severe, postoperative septic complications, such as anastomotic leak, intra-abdominal abscess, and fistula [25]. Published studies on the benefit of initial PCD to reduce the rate of postoperative septic complications demonstrate conflicting results, and the benefit of PCD for this purpose remains unclear [25,26].

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D. Percutaneous catheter drainage only

For mature abscesses associated with appendicitis, an initial combination of PCD, antibiotics, bowel rest, and (on occasion) hyperalimentation has been advocated. In a retrospective review of 80 cases, nonoperative management was associated with a significantly lower rate of complications and a significantly shorter hospital stay compared with operative management [8]. In addition, PCD has shown to result in rapid clinical improvement in children with intra-abdominal infections secondary to perforated appendicitis [9].

PCD is advocated for larger collections with a reported efficacy ranging from 70% to 90% [10,11]. Peritoneal signs, active hemorrhage, lack of maturation of the abscess wall, and anatomic constraints have been suggested as contraindications to PCD [12]. The timing of abscess drainage is still open to debate with no clinical trials available that identify an optimal time period for drainage. However, timely drainage is of clear clinical benefit [2]. The highest success rates have been achieved for abscesses resulting from recent laparotomy [11,13,14], and, as a result, PCD with antibiotics is usually the only treatment required for this entity. For diverticular abscesses, a retrospective review of 218 patients showed that PCD with antibiotics obviated the need for subsequent colectomy in 85% of cases [15].

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E. Surgical drainage

Abdominal abscesses are most often the result of diverticulitis, appendicitis, Crohn disease, and recent laparotomy. When possible, OSD is avoided because of a high rate of morbidity and mortality [29,30]. A recent retrospective study has demonstrated that early appendectomy compared with conservative nonsurgical management with subsequent appendectomy results in lower hospital costs and less health care utilization [31].

Variant 2: Patient with a history of left hemicolectomy 2 months ago for colon carcinoma. Two weeks after placement of a drain into an abdominal abscess; the patient presents with abdominal pain and fever. Drain output is 25 cc per day and the collection is unchanged in size by CT. Treatment includes antibiotics.

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A. Catheter upsizing

Persistence of fluid collections despite PCD may be the result of factors such as complex loculations and septations; fistulization of the cavity to the enteric, biliary, genitourinary, pancreatic, or bronchial systems; the presence of neoplastic tissue; and communication of the cavity to the lymphatic system. Depending on the reason for incomplete drainage, options may include catheter manipulation, catheter upsizing, diversion of upstream obstructions, or surgical drainage—both open and laparoscopic. A study of second PCD of recurrent intra-abdominal and pelvic abscesses reported a secondary drainage rate of 4.9% [32]. In a retrospective study of 82 abscesses that were refractory to PCD and clinical management, catheter exchange resulted in clinical success without surgery in 76.8% of cases [33].

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B. Continued antibiotics and drain removal

Removal of the drain with continued treatment with antibiotics alone for a persistent collection is not appropriate management. Criteria for drain removal includes resolution of signs of infection, catheter output <10 to 20 cc, and resolution of the abscess on repeat imaging [2]. Depending on the reason for incomplete drainage, options may include catheter manipulation, catheter upsizing, diversion of upstream obstructions, or surgical drainage, both open and laparoscopic as discussed above.

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C. Continued antibiotics and drainage (no change in care)

On occasion, PCD fails to resolve the associated fluid collection despite these measures. In such circumstances, the benefit of PCD may be to limit the hematogenous or local spread of infection and improve the acute clinical presentation, thereby preparing the patient for an elective, single-step surgical procedure. This treatment algorithm has been described for appendicitis and Crohn disease [23]. For cases of fistulization of the abscess cavity to enteric, biliary, genitourinary, pancreatic, or bronchial systems, PCD may be successful with prolonged catheterization [47,48].

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D. Intracavitary thrombolytic therapy and drainage

Fibrinolysis of complex, multiseptated fluid collections refractory to PCD by intracavitary instillation of fibrinolytic agents, such as tissue plasminogen activator, has been reported [34-36].

Available reports are limited in number, and often small but high rates of clinical success have been demonstrated retrospectively for abdominal and pelvic abscesses [34] as well as organizing hemothorax and empyema [36]. Case reports have even demonstrated success in the fibrinolytic treatment of refractory, complex splenic abscesses [37]. In a prospective study of 100 patients with abdominal abscesses randomized to regular instillation of sterile saline versus urokinase during catheter drainage, the urokinase group had no increase in complication rate [38]. However, in a smaller prospective, randomized study of 20 patients with complicated intra-abdominal abscesses, patients receiving intracavitary alteplase showed a 72% clinical success rate compared with 22% for patients receiving sterile saline [39]. Rates of bleeding complications using intracavitary recombinant tissue plasminogen activator have been low to zero for pelvic, abdominal, and chest collections, except for a 33% rate of pleural hemorrhage noted for intrapleural recombinant tissue plasminogen activator for patients on anticoagulation [36].

Enteric or biliary fistulas have been treated with a variety of therapies with varied success, though a recent series of 11 cases treated with *n*-butyl cyanoacrylate glue within the cavity and fistula tract resulted in 100% clinical success [40].

For persistent sterile collections such as cysts, lymphoceles, and seromas, a number of reports describe high rates of success in shortening the period of catheterization by intracavitary instillation of sclerotherapy agents such as ethanol, doxycycline, or tetradecyl sulfate [41].

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E. Laparoscopic drainage

Laparoscopic drainage has been shown to be an effective option for complicated abdominal abscesses. A retrospective study of 7 patients demonstrated successful drainage in all patients without recurrent abscess formation and no complications [42]. A reported advantage of laparoscopic drainage is direct visualization of purulent material and the ability to explore the abdominal cavity [43].

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F. Open surgical drainage

Previous studies have estimated that approximately one-third of abdominal abscesses may not be amenable to PCD [44]. There is a paucity of literature that has studied the indications for OSD versus laparoscopic drainage versus PCD. As such, the decision to pursue OSD should be made based on prior management, patient characteristics, and location. If a persistent intra-abdominal abscess is due to another underlying process that requires surgical management (ie, bowel perforation), OSD may be the best approach. OSD is often a complementary approach to PCD. PCD may be the initial approach for complex abscesses in patients with multiple comorbidities in order to better optimize them for eventual elective OSD [45].

PCD of an infected or fluid-filled tumor may be inadvertent or intentional. For good surgical candidates, tumor resection is typically performed. For poor surgical candidates, the period of catheterization may be markedly prolonged or indefinite [46]. Despite this finding, patients with infected, inoperable tumors at risk for systemic infection may opt for PCD.

Variant 3: Patient who is an intravenous drug abuser presents with fever and tachycardia and on imaging is found to have 2 noncommunicating splenic abscesses accessible percutaneously through a 1 cm rim of normal splenic tissue. Treatment includes antibiotics.

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A. Conservative management only

Cases of splenic abscess management with antibiotics alone do exist [55,57]; however, intervention (either surgical or PCD) is often required given the high mortality from untreated sepsis [57].

Variant 3: Patient who is an intravenous drug abuser presents with fever and tachycardia and on imaging is found to have 2 noncommunicating splenic abscesses accessible percutaneously through a 1 cm rim of normal splenic tissue. Treatment includes antibiotics.

B. Needle aspiration

Needle aspiration is often pursued as part of the diagnostic workup [54,56]. A small series of patients treated with needle aspiration alone demonstrated that this approach is safe and effective for some patients with bacterial splenic abscesses. The authors suggested that percutaneous aspiration may aid in nonoperative healing or alternatively may be a technique to temporize patients who are not yet medically optimized for surgery [54].

Variant 3: Patient who is an intravenous drug abuser presents with fever and tachycardia and on imaging is found to have 2 noncommunicating splenic abscesses accessible percutaneously through a 1 cm rim of normal splenic tissue. Treatment includes antibiotics.

C. Percutaneous catheter drainage only

Current data on the management of splenic abscesses are relatively sparse, and treatment choices, even within a single institution, are often variable [49,50]. Splenic abscesses were considered to be surgical cases as recently as the 1990s, but a number of small, retrospective series [51,52] have readdressed this issue, some advocating the benefits of PCD for solitary, simple collections and splenectomy for multiple collections. In a retrospective study of 18 children with splenic abscesses, IV antibiotics were administered to all patients, and 10 underwent PCD for the inclusionary threshold of an abscess diameter >3 cm. The clinical response rate was 100% [53]. Preservation of splenic function is maintained by the use of PCD techniques, and this should be attempted where possible and safe. PCD does carry a risk of hemorrhage if a nontarget puncture occurs; thus, in these cases in which there is no favorable window for intervention, splenectomy is often performed [50].

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D. Splenectomy

There is a wide range of reported failure rates of PCD for splenic abscess (14.3%–75%) [54]. As such, splenectomy for splenic abscess is still commonly performed, especially for patients with complex or multiple splenic abscesses [55]. Splenectomy is also indicated if there is no window for PCD or if the patient is at high risk of bleeding [50]. Another option for splenic preservation is laparoscopic drainage, which has been successfully attempted in pediatric patients, though there is a paucity of data on this approach [50].

Variant 4: Patient with abdominal pain radiating to the back 5 weeks after hospitalization for acute pancreatitis. Afebrile. CT scan shows a walled-off collection in the body of the pancreas indenting a broad portion of the body of the stomach, affecting the gastric outlet. The collection is percutaneously accessible with a 3-cm window. MR cholangiopancreatography shows a patent pancreatic duct.

A significant amount of confusing terminology is used when discussing pancreatitis, including acute and subacute fluid collections. Operators are urged to adhere to standards such as the revised Atlanta classification when describing such collections [58]. Under the revised Atlanta classification system, four distinct collection subtypes exist based on the presence or absence of pancreatic necrosis and time since the onset of pancreatitis (acute within 4 weeks of pancreatitis onset; chronic after >4 weeks of pancreatitis onset) [59,60]. Non-necrotic collections are termed acute peripancreatic fluid collections and pseudocysts (chronic). Necrotic collections are termed acute necrotic collections and walled-off necrosis (chronic) [59]. The use of the term pancreatic abscess is discouraged. Instead, any of the subtypes of pancreatic collections under the revised

Atlanta criteria can become infected. Infected pancreatic collections are associated with a high rate of mortality and are drained emergently.

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A. Conservative management only

Pancreatic pseudocysts may resolve spontaneously if they are small, stable, and sterile. Drainage is generally advocated for large (≥ 5 cm) pseudocysts; however, under the revised criteria, size alone does not warrant treatment [59] of rapidly enlarging, painful, obstructing, or infected pseudocysts. Techniques for drainage are multidisciplinary [64,70], and continued disagreement of the optimal use of these techniques leads to a variety of treatment algorithms for these patients.

Renal abscesses may be cured by medical treatment in over half of cases [71] and even up to 64% of cases [72].

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B. Endoscopic cystgastrostomy

A randomized comparative trial demonstrated that endoscopic approaches are associated with shorter hospital stays and greater patient-reported mental and physical outcomes when compared with surgical drainage [61]. High rates of clinical success have been reported using endoscopic techniques [62,63], which may be optimal for more central collections and those abutting the greater curvature of the stomach.

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C. Percutaneous catheter drainage only

PCD generally requires a prolonged period of drainage in these patients compared with abscesses in other locations, but high rates of eventual success have been reported [64]. Complete occlusion of the main pancreatic duct central to the pseudocyst may lead to failure of PCD and necessitate use of surgical or endoscopic marsupialization to the bowel. When compared with endoscopic approaches, PCD has similar clinical success rates for symptomatic pseudocysts, but PCD is associated with higher rates of reintervention, longer length of hospital stay, and increased number of follow-up abdominal imaging studies [65]. A study of patients with acute necrotic collections and walled-off necrosis demonstrated that early and late PCD results in similar efficacy and safety profiles [66]. In addition, persistent organ failure is the most common indication for PCD in patients with acute necrotic collections, and suspected infection is the most common indication for PCD in patients with walled-off necrosis [66].

For suboptimal surgical candidates, minimally invasive alternatives include endoscopic drainage or PCD [62,64,67,68]. PCD is typically used as a temporizing measure prior to surgery because cure rates range from 14% to 32% [67-69]. Large, complex collections involving the tail of the pancreas or those collections not in direct communication with the pancreas may be better treated by PCD.

Both renal and perirenal abscesses may otherwise require PCD, surgical drainage, or nephrectomy.

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D. Percutaneous needle aspiration

Needle aspiration of pancreatic cystic lesions is primarily a diagnostic tool [73,74]. Needle aspiration can help to distinguish benign pancreatic lesions, such as pseudocysts, from more aggressive cystic and solid pancreatic lesions. Needle aspiration is not routinely performed for therapeutic purposes for pancreatic collections.

Similarly, needle aspiration can also be used for diagnosis of renal and perirenal cystic lesions; however, there have been cases of needle aspiration of renal abscesses with successful results [75].

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E. Surgical cystenterostomy

Surgical drainage, both open and laparoscopic, is efficacious with reported pseudocyst recurrence rates between 2.5% to 5% [60]. Initial comparisons of surgical versus endoscopic drainage demonstrated similar success and complication rates; however, with the advent of newer endoscopic techniques, endoscopic approaches are the preferred approach.

Both renal and perirenal abscesses may otherwise require PCD, surgical drainage, or nephrectomy.

Variant 5: Patient with a 2 week history of cough, fever, and foul-smelling sputum. Worsening condition despite a full course of broad-spectrum antibiotics. Sputum cultures negative. CT scan shows a right lower lobe abscess. Treatment includes antibiotics.

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A. Another course of antibiotics and postural drainage

The majority of lung abscesses (typically >80%) are treated to resolution with antibiotics and conservative management [80,83]. PCD and surgical resection or drainage are generally reserved for cases that persist or worsen despite antibiotics [76-78].

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B. Needle aspiration

Needle aspiration can be performed for diagnostic fluid culture. However, the organism is usually determined by culture of sputum or blood and, less optimally, by culture of cavitory fluid obtained by needle aspiration or bronchoscopy. Optimal management should be determined based on the discussion above.

Variant 5: Patient with a 2 week history of cough, fever, and foul-smelling sputum.

Worsening condition despite a full course of broad-spectrum antibiotics. Sputum cultures negative. CT scan shows a right lower lobe abscess. Treatment includes antibiotics.

C. Percutaneous catheter drainage only

Parenchymal lung abscesses most often occur from aspiration of anaerobic oropharyngeal bacteria or from fungal organisms. Alcoholics, immunocompromised patients, and patients with bronchial obstruction are predisposed. PCD and surgical resection or drainage are generally reserved for cases that persist or worsen despite antibiotics [76-78]. In a retrospective study of 40 patients with lung abscesses refractory to antibiotic therapy, complete resolution was achieved with PCD in 83% of patients, and the remainder required surgery [79]. Chest tube drainage of lung abscesses has been reported to be definitive in 84% of cases with a complication rate of 16% [80]. Complications of PCD include spillage of infection into other portions of the lung, bleeding, empyema, and bronchopleural fistula [76]. Endoscopic drainage of lung abscesses can also be attempted in patients with central abscesses, multiple comorbidities, and coagulopathies, but they carry the risk of spillage of infected material throughout the lung [76]. Mediastinal abscesses are most commonly the result of thoracic surgical procedures and usually require PCD. Though these cases may be technically challenging, one study showed low complication rates, technical success rates approaching or reaching 100%, and clinical success rates exceeding 90% without the need for surgery [81].

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Worsening condition despite a full course of broad-spectrum antibiotics. Sputum cultures negative. CT scan shows a right lower lobe abscess. Treatment includes antibiotics.

D. Surgery

Surgical resection of lung abscesses is required in approximately 10% of cases [76]. Indications for surgical resection include prolonged sepsis, hemoptysis, bronchopleural fistula, empyema, lung abscess persisting >6 weeks with antibiotic treatment, and suspected cancer [76]. For large abscesses, lobectomy may be required; however, segmentectomy can be performed if the entire abscess and necrotic lung tissue can be removed [82].

Variant 6: Patient with a 3 week history of pneumonia, fever, dyspnea. Worsening condition despite a full course of broad-spectrum antibiotics. CT scan shows a loculated pleural collection with overlying pleural thickening (empyema). Treatment includes antibiotics.

Variant 6: Patient with a 3 week history of pneumonia, fever, dyspnea. Worsening condition despite a full course of broad-spectrum antibiotics. CT scan shows a loculated pleural collection with overlying pleural thickening (empyema). Treatment includes antibiotics.

A. Another course of antibiotics and postural drainage

Although systemic antibiotics are required for the successful management of empyema, pleural drainage in some form must also be performed (eg, PCD and surgical decortication) [84,86]. Postural drainage would not be appropriate for the management of empyema.

Variant 6: Patient with a 3 week history of pneumonia, fever, dyspnea. Worsening condition

despite a full course of broad-spectrum antibiotics. CT scan shows a loculated pleural collection with overlying pleural thickening (empyema). Treatment includes antibiotics.

B. Needle aspiration

Needle aspiration (thoracentesis) can be performed for fluid culture [84]. However, the organism is usually determined by culture of sputum or blood and, less optimally, by culture of cavitory fluid obtained by needle aspiration or bronchoscopy. Thoracentesis alone is helpful in uncomplicated pleural effusions but is not recommended for the management of empyema [84,86].

Variant 6: Patient with a 3 week history of pneumonia, fever, dyspnea. Worsening condition despite a full course of broad-spectrum antibiotics. CT scan shows a loculated pleural collection with overlying pleural thickening (empyema). Treatment includes antibiotics.

C. Open decortication

In later-stage empyema with extensive fibrous septa formation or scar formation, surgical management is often required, either video assisted or open decortication [87]. A recent meta-analysis compared VATS decortication with open decortication. The results suggested that the VATS approach is comparable to or slightly better than open decortication with regard to operative time, hospital stay, and overall morbidity and mortality. There was no difference between relapse rates between the 2 techniques [87]. However, the American Association for Thoracic Surgeons recommends VATS decortication as the first-line surgical approach in patients with stage II acute empyema [84].

Variant 6: Patient with a 3 week history of pneumonia, fever, dyspnea. Worsening condition despite a full course of broad-spectrum antibiotics. CT scan shows a loculated pleural collection with overlying pleural thickening (empyema). Treatment includes antibiotics.

D. Percutaneous catheter drainage with administration of thrombolytic therapy

Persistent, complex collections and organizing hemothoraces have been successfully treated with instillation of fibrinolytic agents [36,84]. However, a meta-analysis of fibrinolytic therapy concluded that there is not enough evidence to support the use of fibrinolytics routinely for empyemas [84,85].

Variant 6: Patient with a 3 week history of pneumonia, fever, dyspnea. Worsening condition despite a full course of broad-spectrum antibiotics. CT scan shows a loculated pleural collection with overlying pleural thickening (empyema). Treatment includes antibiotics.

E. Video-assisted thoracic surgery decortication

In later-stage empyema with extensive fibrous septa formation or scar formation, surgical management is often required, either video assisted or open decortication [87]. A recent meta-analysis compared video-assisted thoracic surgery (VATS) decortication with open decortication. The results suggested that the VATS approach is comparable to or slightly better than open decortication with regard to operative time, hospital stay, and overall morbidity and mortality. There was no difference between relapse rates between the 2 techniques [87]. However, the American Association for Thoracic Surgeons recommends VATS decortication as the first-line surgical approach in patients with stage II acute empyema [84].

Variant 7: Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian abscess (TOA) greater than 3 cm. Treatment includes antibiotics.

Variant 7: Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian

abscess (TOA) greater than 3 cm. Treatment includes antibiotics.

A. Conservative management only

Small TOAs tend to resolve with antibiotics alone [99]. In a retrospective study of 122 patients, nearly two-thirds of TOAs resolved with antibiotics and supportive care [100]. However, early aspiration (for simple collections) and drainage (for complex collections) have been advocated to prevent prolongation of the disease and the potential associated loss of fertility.

Variant 7: Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian abscess (TOA) greater than 3 cm. Treatment includes antibiotics.

B. Endoscopic US-guided drainage

When collections are inaccessible by all of these techniques, open surgical intervention may be avoided in some cases by endoscopic US-guided transrectal or transcolonic drainage without fluoroscopy [104,105].

Variant 7: Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian abscess (TOA) greater than 3 cm. Treatment includes antibiotics.

C. Surgical/laparoscopic drainage

Salpingo-oophorectomy and OSD may become necessary in refractory cases and may be more commonly required for TOAs of gastrointestinal rather than gynecological origin [101]. Rupture of a TOA is a surgical emergency that warrants immediate washout [102]. Laparoscopic drainage can also be performed [103].

Variant 7: Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian abscess (TOA) greater than 3 cm. Treatment includes antibiotics.

D. Transabdominal needle aspiration

See the transvaginal needle aspiration discussion above. The choice of route for a given abscess varies among operators, institution type, patient habitus, and abscess location.

Variant 7: Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian abscess (TOA) greater than 3 cm. Treatment includes antibiotics.

E. Transabdominal percutaneous catheter drainage

See the transvaginal PCD discussion above. Depending on location, pelvic fluid collections can be drained via the transabdominal, transgluteal, transrectal, transvaginal, transperineal, and transvesicular routes. The efficacy and safety of these routes have been established by a number of retrospective reports [88-94]. The choice of route for a given abscess varies among operators and institution type, with transrectal and transvaginal approaches used much more commonly in academic centers [95]. In general, reports have advocated the use of the most sterile route possible when aspirating or draining a potentially sterile collection.

For prostatic abscesses, the longstanding treatment method has been transurethral drainage, but recent small studies have demonstrated that guidance of needle aspiration or placement of small-bore pigtail catheters using transrectal US can shorten hospital stay [98] and provide a viable alternative.

Variant 7: Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked

tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian abscess (TOA) greater than 3 cm. Treatment includes antibiotics.

F. Transgluteal needle aspiration

See the transvaginal needle aspiration discussion above. The choice of route for a given abscess varies among operators, institution type, patient habitus, and abscess location.

Variant 7: Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian abscess (TOA) greater than 3 cm. Treatment includes antibiotics.

G. Transgluteal percutaneous catheter drainage

See the transvaginal PCD discussion above. Depending on location, pelvic fluid collections can be drained via the transabdominal, transgluteal, transrectal, transvaginal, transperineal, and transvesicular routes. The efficacy and safety of these routes have been established by a number of retrospective reports [88-94]. The choice of route for a given abscess varies among operators and institution type, with transrectal and transvaginal approaches used much more commonly in academic centers [95]. In general, reports have advocated the use of the most sterile route possible when aspirating or draining a potentially sterile collection.

Variant 7: Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian abscess (TOA) greater than 3 cm. Treatment includes antibiotics.

H. Transrectal needle aspiration

See the transvaginal needle aspiration discussion above. The choice of route for a given abscess varies among operators, institution type, patient habitus, and abscess location.

Variant 7: Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian abscess (TOA) greater than 3 cm. Treatment includes antibiotics.

I. Transrectal percutaneous catheter drainage

See the transvaginal PCD discussion above. Depending on location, pelvic fluid collections can be drained via the transabdominal, transgluteal, transrectal, transvaginal, transperineal, and transvesicular routes. The efficacy and safety of these routes have been established by a number of retrospective reports [88-94]. The choice of route for a given abscess varies among operators and institution type, with transrectal and transvaginal approaches used much more commonly in academic centers [95]. In general, reports have advocated the use of the most sterile route possible when aspirating or draining a potentially sterile collection.

For prostatic abscesses, the longstanding treatment method has been transurethral drainage, but recent small studies have demonstrated that guidance of needle aspiration or placement of small-bore pigtail catheters using transrectal US can shorten hospital stay [98] and provide a viable alternative.

Variant 7: Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian abscess (TOA) greater than 3 cm. Treatment includes antibiotics.

J. Transvaginal needle aspiration

Early TOA aspiration (for simple collections) has been advocated to prevent prolongation of the disease and the potential associated loss of fertility [99]. Needle aspiration is also helpful for

diagnosis. Fluid culture can be used to guide antibiotic management [99]. The choice of route for a given abscess varies among operators, institution type, patient habitus, and abscess location.

Variant 7: Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian abscess (TOA) greater than 3 cm. Treatment includes antibiotics.

K. Transvaginal percutaneous catheter drainage

Depending on location, pelvic fluid collections can be drained via the transabdominal, transgluteal, transrectal, transvaginal, transperineal, and transvesicular routes. The efficacy and safety of these routes have been established by a number of retrospective reports [88-94]. The choice of route for a given abscess varies among operators and institutions, with transrectal and transvaginal approaches used much more commonly in academic centers [95]. In general, reports have advocated the use of the most sterile route possible when aspirating or draining a potentially sterile collection. Using this rationale, the transabdominal and transgluteal routes would be preferable to the endocavitary routes for a potentially sterile collection. The transperineal route is most commonly used in patients after low anterior resection for rectal cancer [93]. Some disagreement exists in the literature regarding the level and incidence of significant or persistent pain when comparing the transgluteal and endocavitary routes. At a minimum, conscious sedation is required for these procedures. The route of transgluteal drainage through the greater sciatic foramen should be medial to the sciatic nerves and below the level of the piriformis muscle to prevent the complications of persistent pain [90] or injury to the gluteal arteries.

For women of reproductive age desiring pregnancy, if tubo-ovarian abscess (TOA) exists without intra-abdominal rupture, medical management and early drainage results in pregnancy rates of 32% to 63% compared with 4% to 15% with medical management alone [96,97]. The route and method of drainage depends on operator and patient preference, as well as individual anatomic considerations.

Variant 8: Patient with recent endoscopic retrograde cholangiopancreatography and sphincterotomy now with 3 weeks of worsening right upper quadrant pain, fever, jaundice, and malaise. CT scan reveals 2 liver abscesses greater than 3 cm. MRCP demonstrates no biliary obstruction or stones. Treatment includes antibiotics.

Variant 8: Patient with recent endoscopic retrograde cholangiopancreatography and sphincterotomy now with 3 weeks of worsening right upper quadrant pain, fever, jaundice, and malaise. CT scan reveals 2 liver abscesses greater than 3 cm. MRCP demonstrates no biliary obstruction or stones. Treatment includes antibiotics.

A. Continued conservative management

For pyogenic abscesses <3 to 5 cm in diameter, authors have advocated using antibiotics, either alone or in conjunction with needle aspiration [108,114,115], with excellent success rates. Amebic abscesses have been shown to respond extremely well to antibiotics without intervention, regardless of size, but occasionally they require needle aspiration [114].

Variant 8: Patient with recent endoscopic retrograde cholangiopancreatography and sphincterotomy now with 3 weeks of worsening right upper quadrant pain, fever, jaundice, and malaise. CT scan reveals 2 liver abscesses greater than 3 cm. MRCP demonstrates no biliary obstruction or stones. Treatment includes antibiotics.

B. Needle aspiration

For pyogenic abscesses <3 to 5 cm in diameter, authors have advocated using antibiotics, either

alone or in conjunction with needle aspiration [108,114,115], with excellent success rates.

Amebic abscesses have been shown to respond extremely well to antibiotics without intervention, regardless of size, but occasionally they require needle aspiration [114]. For hepatic echinococcal cysts, percutaneous and surgical treatment options are available. For single compartment cysts that are percutaneously accessible and not in communication with the biliary system, percutaneous aspiration injection and reaspiration therapy can be attempted, depending on medical treatment response and cyst size [116,117]. Briefly, percutaneous aspiration injection and reaspiration involves aspiration of cyst contents and injection of a scolical agent, followed by reaspiration of the cyst contents [116-118].

Variant 8: Patient with recent endoscopic retrograde cholangiopancreatography and sphincterotomy now with 3 weeks of worsening right upper quadrant pain, fever, jaundice, and malaise. CT scan reveals 2 liver abscesses greater than 3 cm. MRCP demonstrates no biliary obstruction or stones. Treatment includes antibiotics.

C. Percutaneous catheter drainage only

Hepatic abscesses may be treated differently depending on their size and etiology. Pyogenic abscesses most often result from portal venous seeding of diverticulitis and appendicitis, but they also may occur from obstruction of the biliary system, including the gallbladder. Pyogenic abscesses complicate 1.4% of hepatic artery embolization procedures [106]. Morbidity and mortality from pyogenic abscess may be increased in patients undergoing hepatic artery embolization who have a history of bilioenteric anastomosis or an incompetent sphincter of Oddi. Mortality is also high for abscesses associated with malignancy, though PCD is clinically successful in approximately two-thirds of such cases [107].

For pyogenic abscesses >4 to 5 cm in diameter, PCD or aspiration is often required [108]. PCD appears to be more effective than needle aspiration [109]. Clinical success may be influenced by the infecting organism. A study of 48 patients with unilocular hepatic abscesses >3 cm treated with PCD and antibiotic therapy demonstrated a success rate of 83% [108,110].

Variant 8: Patient with recent endoscopic retrograde cholangiopancreatography and sphincterotomy now with 3 weeks of worsening right upper quadrant pain, fever, jaundice, and malaise. CT scan reveals 2 liver abscesses greater than 3 cm. MRCP demonstrates no biliary obstruction or stones. Treatment includes antibiotics.

D. Percutaneous catheter drainage with conversion to percutaneous biliary drain

Some hepatic abscesses may develop communication with the biliary system, resulting in bile leak. Currently, there are no guidelines for the management of liver abscesses with biliary communication [111]. In such cases, biliary drainage or diversion can be performed for hepatic abscesses that have ruptured into the biliary system [112]. Some studies have shown that hepatic abscesses with biliary communication do not heal with percutaneous abscess drainage alone, and biliary stenting or drainage was required to achieve complete cure [113]. A prospective study of endoscopic biliary drainage (ie, sphincterotomy plus either stent or nasobiliary drainage catheter placement) demonstrated successful healing on biliary fistula/bile leaks that resulted from hepatic abscess after therapy [111]. Most studies in the current literature utilize an endoscopic approach for biliary drainage [111-113]. Percutaneous biliary drainage can also be attempted for bile leak secondary to abscess rupture into the biliary system depending on institutional preference. A percutaneous approach may need to be taken if an endoscopic approach is not feasible. However, there is a paucity of data specifically about the efficacy of percutaneous biliary drainage for hepatic

abscess rupture or fistulization into the biliary system.

Variant 8: Patient with recent endoscopic retrograde cholangiopancreatography and sphincterotomy now with 3 weeks of worsening right upper quadrant pain, fever, jaundice, and malaise. CT scan reveals 2 liver abscesses greater than 3 cm. MRCP demonstrates no biliary obstruction or stones. Treatment includes antibiotics.

E. Surgical management

In patients with large multiloculated hepatic abscesses, the success rate for PCD and antibiotic therapy was 33% versus 100% in patients who underwent surgical drainage [110]. PCD failure occurs in 15% to 36% of cases [119,120]. Predictors of PCD failure for hepatic abscesses include multiloculation, high viscosity or necrotic contents, and hypoalbuminemia [110,120,121]. Larger abscesses (>5 cm) or abscesses without a percutaneous approach may be best managed surgically [110,121]. However, surgical drainage of hepatic abscesses has a high mortality rate at 10% to 47% [108].

For cysts that are percutaneously inaccessible, complex, and communicate with the biliary structures, surgical cystectomy can be performed, depending on prior medical therapy and the patient's clinical status [116]. It is important to note that cyst rupture or spillage of cyst contents can result in anaphylaxis. In cases of cyst content spillage during surgical resection, immediate washout with hypertonic saline and a scolical agent must be performed [116].

Variant 9: Patient presents to the emergency department with 5 days of progressive ankle swelling and 2 days of fever. An ultrasound was obtained given the diffuse soft-tissue swelling around the ankle which revealed a subperiosteal abscess. Treatment includes antibiotics.

Variant 9: Patient presents to the emergency department with 5 days of progressive ankle swelling and 2 days of fever. An ultrasound was obtained given the diffuse soft-tissue swelling around the ankle which revealed a subperiosteal abscess. Treatment includes antibiotics.

A. Continued conservative management

Drainage of subperiosteal abscesses is often required for proper management as discussed above.

Variant 9: Patient presents to the emergency department with 5 days of progressive ankle swelling and 2 days of fever. An ultrasound was obtained given the diffuse soft-tissue swelling around the ankle which revealed a subperiosteal abscess. Treatment includes antibiotics.

B. Needle aspiration

Needle aspiration can be performed for confirmation of diagnosis, but the subperiosteal abscess will often recur with needle aspiration alone [126]. There have been reports of successful treatment of subperiosteal abscess associated with acute mastoiditis with needle aspiration and antibiotics, but most published literature reports surgical management [127].

Variant 9: Patient presents to the emergency department with 5 days of progressive ankle swelling and 2 days of fever. An ultrasound was obtained given the diffuse soft-tissue swelling around the ankle which revealed a subperiosteal abscess. Treatment includes antibiotics.

C. Percutaneous catheter drainage only

Percutaneous drainage of subperiosteal abscesses has been reported with mixed success, but

overall there is a paucity of data supporting this approach [122].

Variant 9: Patient presents to the emergency department with 5 days of progressive ankle swelling and 2 days of fever. An ultrasound was obtained given the diffuse soft-tissue swelling around the ankle which revealed a subperiosteal abscess. Treatment includes antibiotics.

D. Surgical drainage

Subperiosteal abscess is a rare complication of pyogenic osteomyelitis that most often occurs in pediatric patients [123]. The primary management of these abscesses is surgical incision and drainage followed by antibiotic therapy [124]. It is important to note that most cases of subperiosteal abscess occur in the setting of acute sinusitis most commonly affecting the frontal sinus and mastoid. The primary management of these abscesses involving the sinuses or calvarium is surgical drainage and antibiotics [125].

Summary of Highlights

- **Variant 1:** PCD followed by delayed surgery or PCD only is usually appropriate for a patient with right lower quadrant abdominal pain, fever, and leukocytosis for 7 days. The physical examination shows no peritoneal signs with a CT scan showing a thin-walled fluid collection, >3 cm, adjacent to the cecum, nonvisualization of the appendix, and an appendicolith. Imaging findings are highly suspicious for perforated appendicitis. Treatment includes antibiotics. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 2:** Catheter upsizing or intracavitary thrombolytic therapy and drainage is usually appropriate for a patient with a history of left hemicolectomy 2 months prior for colon carcinoma. Two weeks after placement of a drain into an abdominal abscess, the patient presents with abdominal pain and fever. Drain output is 25 cc per day, and the collection is unchanged in size by CT. Treatment includes antibiotics. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 3:** PCD only or splenectomy is usually appropriate for a patient who is an IV drug abuser presenting with fever and tachycardia. Imaging is found to have two noncommunicating splenic abscesses accessible percutaneously through a 1-cm rim of normal splenic tissue. Treatment includes antibiotics. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 4:** Endoscopic cystgastrostomy is usually appropriate for a patient with abdominal pain radiating to the back 5 weeks after hospitalization for acute pancreatitis. The patient is afebrile with a CT scan showing a walled-off collection in the body of the pancreas indenting a broad portion of the body of the stomach, affecting the gastric outlet. The collection is percutaneously accessible with a 3-cm window, and the MR cholangiopancreatography shows a patent pancreatic duct.
- **Variant 5:** PCD only or surgery may be appropriate for a patient with a 2-week history of cough, fever, and foul-smelling sputum. The patient has a worsening condition despite a full course of broad-spectrum antibiotics. Sputum cultures are negative, with a CT scan showing a right lower lobe abscess. Treatment includes antibiotics. The panel did not agree on recommending another course of antibiotics and postural drainage for a patient in this

clinical scenario. There is insufficient medical literature to conclude whether or not these patients would benefit from another course of antibiotics and postural drainage for this clinical scenario. Intervention in this patient population is controversial but may be appropriate.

- **Variant 6:** PCD with administration of thrombolytic therapy or VATS decortication is usually appropriate for a patient with a 3-week history of pneumonia, fever, and dyspnea. The patient has a worsening condition despite a full course of broad-spectrum antibiotics. CT scan shows a loculated pleural collection with overlying pleural thickening (empyema). Treatment includes antibiotics. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 7:** Transabdominal PCD, transgluteal PCD, transrectal PCD, or transvaginal PCD is usually appropriate for a woman of childbearing age with abdominal pain, fever, and leukocytosis. The approach is dependent on the specific location of the pelvic collection, allowing for a safe window. There is marked tenderness on the pelvic examination and a CT scan shows a walled-off, probable TOA >3 cm. Treatment includes antibiotics. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 8:** PCD only is usually appropriate for a patient with recent endoscopic retrograde cholangiopancreatography and sphincterotomy now with 3 weeks of worsening right upper quadrant pain, fever, jaundice, and malaise. A CT scan reveals 2 liver abscesses >3 cm and a MR cholangiopancreatography demonstrates no biliary obstruction or stones. Treatment includes antibiotics.
- **Variant 9:** Surgical drainage is usually appropriate for a patient presenting to the emergency department with 5 days of progressive ankle swelling and 2 days of fever. A US was obtained given the diffuse soft-tissue swelling around the ankle, which revealed a subperiosteal abscess. Treatment includes antibiotics.

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at <https://acsearch.acr.org/list>. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at <https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria>.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an

		alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

References

1. Roberts BW.. CT-guided Intra-abdominal Abscess Drainage. [Review]. Radiol Technol. 87(2):187CT-203CT; quiz 204CT-7, 2015 Nov-Dec.
2. Charles HW.. Abscess drainage. [Review]. SEMIN. INTERVENT. RADIOL.. 29(4):325-36, 2012 Dec.
3. Bakal CW, Sacks D, Burke DR, et al. Quality improvement guidelines for adult percutaneous abscess and fluid drainage. J Vasc Interv Radiol. 2003;14(9 Pt 2):S223-225.
4. Arellano RS, Gervais DA, Mueller PR. CT-guided drainage of abdominal abscesses: hydrodissection to create access routes for percutaneous drainage. AJR. 2011;196(1):189-191.
5. Zhou W, Arellano RS. Hydrodissection-Assisted Percutaneous Drainage of Deep Pelvic Abscess. J Vasc Interv Radiol. 28(2):308-310, 2017 Feb.
6. Ciftci TT, Akinci D, Akhan O. Percutaneous transhepatic drainage of inaccessible postoperative abdominal abscesses. AJR Am J Roentgenol. 2012;198(2):477-481.
7. Yamakado K, Takaki H, Nakatsuka A, et al. Percutaneous transhepatic drainage of inaccessible abdominal abscesses following abdominal surgery under real-time CT-fluoroscopic guidance. Cardiovasc Intervent Radiol. 2010;33(1):161-163.
8. Hussain MI, Al-Akeely MH, Alam MK, Al-Qahatani HH, Al-Salamah SM, Al-Ghamdi OA. Management of appendiceal abscess. A 10-year experience in Central Saudi Arabia. Saudi Med J. 2012;33(7):745-749.
9. Bonadio W, Langer M, Cueva J, Haaland A. Impact of Percutaneous Drainage on Outcome of Intra-abdominal Infection Associated With Pediatric Perforated Appendicitis. Pediatr Infect Dis J. 36(10):952-955, 2017 Oct.
10. Akinci D, Akhan O, Ozmen MN, et al. Percutaneous drainage of 300 intraperitoneal abscesses with long-term follow-up. Cardiovasc Intervent Radiol. 28(6):744-50, 2005 Nov-Dec.
11. Cinat ME, Wilson SE, Din AM. Determinants for successful percutaneous image-guided drainage of intra-abdominal abscess. Arch Surg. 2002;137(7):845-849.
12. Parc Y, Frileux P, Schmitt G, Dehni N, Ollivier JM, Parc R. Management of postoperative

peritonitis after anterior resection: experience from a referral intensive care unit. *Dis Colon Rectum*. 2000;43(5):579-587; discussion 587-579.

13. Bouali K, Magotteaux P, Jadot A, et al. Percutaneous catheter drainage of abdominal abscess after abdominal surgery. Results in 121 cases. *J Belge Radiol*. 1993;76(1):11-14.
14. Khurram Baig M, Hua Zhao R, Batista O, et al. Percutaneous postoperative intra-abdominal abscess drainage after elective colorectal surgery. *Tech Coloproctol*. 2002;6(3):159-164.
15. Gaertner WB, Willis DJ, Madoff RD, et al. Percutaneous drainage of colonic diverticular abscess: is colon resection necessary?. *Dis Colon Rectum*. 56(5):622-6, 2013 May.
16. Kaminski A, Liu IL, Applebaum H, Lee SL, Haigh PI. Routine interval appendectomy is not justified after initial nonoperative treatment of acute appendicitis. *Arch Surg*. 2005;140(9):897-901.
17. Simillis C, Symeonides P, Shorthouse AJ, Tekkis PP. A meta-analysis comparing conservative treatment versus acute appendectomy for complicated appendicitis (abscess or phlegmon). *Surgery*. 2010;147(6):818-829.
18. Luo CC, Cheng KF, Huang CS, et al. Therapeutic effectiveness of percutaneous drainage and factors for performing an interval appendectomy in pediatric appendiceal abscess. *BMC surg*. 16(1):72, 2016 Oct 18.
19. Horn CB, Coleoglou Centeno AA, Guerra JJ, Mazuski JE, Bochicchio GV, Turnbull IR. Drain Failure in Intra-Abdominal Abscesses Associated with Appendicitis. *Surg Infect (Larchmt)*. 19(3):321-325, 2018 Apr.
20. Poritz LS, Koltun WA. Percutaneous drainage and ileocelectomy for spontaneous intraabdominal abscess in Crohn's disease. *J Gastrointest Surg*. 2007;11(2):204-208.
21. Shen B.. Interventional IBD: The Role of Endoscopist in the Multidisciplinary Team Management of IBD. *Inflamm Bowel Dis*. 24(2):298-309, 2018 Jan 18.
22. Xie Y, Zhu W, Li N, Li J. The outcome of initial percutaneous drainage versus surgical drainage for intra-abdominal abscesses in Crohn's disease. *Int J Colorectal Dis*. 2012;27(2):199-206.
23. Gervais DA, Hahn PF, O'Neill MJ, Mueller PR. Percutaneous abscess drainage in Crohn disease: technical success and short- and long-term outcomes during 14 years. *Radiology*. 2002;222(3):645-651.
24. Gutierrez A, Lee H, Sands BE. Outcome of surgical versus percutaneous drainage of abdominal and pelvic abscesses in Crohn's disease. *Am J Gastroenterol*. 2006;101(10):2283-2289.
25. Muller-Wille R, Ilesalniks I, Dornia C, et al. Influence of percutaneous abscess drainage on severe postoperative septic complications in patients with Crohn's disease. *Int J Colorectal Dis*. 26(6):769-74, 2011 Jun.
26. Bafford AC, Coakley B, Powers S, et al. The clinical impact of preoperative percutaneous drainage of abdominopelvic abscesses in patients with Crohn's disease. *Int J Colorectal Dis*. 2012;27(7):953-958.
27. Kumar RR, Kim JT, Haukoos JS, et al. Factors affecting the successful management of intra-abdominal abscesses with antibiotics and the need for percutaneous drainage. *Dis Colon Rectum*. 2006;49(2):183-189.

28. Siewert B, Tye G, Kruskal J, et al. Impact of CT-guided drainage in the treatment of diverticular abscesses: size matters. *AJR Am J Roentgenol*. 2006;186(3):680-686.
29. Laopaiboon V, Aphinives C, Prawiset P. Comparison of clinical success between CT-guided percutaneous drainage and open surgical drainage of intra-abdominal fluid collection in Srinagarind Hospital. *J Med Assoc Thai*. 2010;93 Suppl 3:S45-51.
30. vanSonnenberg E, Mueller PR, Ferrucci JT, Jr. Percutaneous drainage of 250 abdominal abscesses and fluid collections. Part I: Results, failures, and complications. *Radiology*. 1984;151(2):337-341.
31. Church JT, Klein EJ, Carr BD, Bruch SW. Early appendectomy reduces costs in children with perforated appendicitis. *J Surg Res*. 220:119-124, 2017 Dec.
32. Gervais DA, Ho CH, O'Neill MJ, Arellano RS, Hahn PF, Mueller PR. Recurrent abdominal and pelvic abscesses: incidence, results of repeated percutaneous drainage, and underlying causes in 956 drainages. *AJR Am J Roentgenol*. 182(2):463-6, 2004 Feb.
33. Gee MS, Kim JY, Gervais DA, Hahn PF, Mueller PR. Management of abdominal and pelvic abscesses that persist despite satisfactory percutaneous drainage catheter placement. *AJR Am J Roentgenol*. 2010;194(3):815-820.
34. Beland MD, Gervais DA, Levis DA, Hahn PF, Arellano RS, Mueller PR. Complex abdominal and pelvic abscesses: efficacy of adjunctive tissue-type plasminogen activator for drainage. *Radiology*. 2008;247(2):567-573.
35. Falsarella PM, Rocha RD, Rahal Junior A, Mendes GF, Garcia RG. Minimally invasive treatment of complex collections: safety and efficacy of recombinant tissue plasminogen activator as an adjuvant to percutaneous drainage. *Radiol. Bras.*. 51(4):231-235, 2018 Jul-Aug.
36. Gervais DA, Levis DA, Hahn PF, Uppot RN, Arellano RS, Mueller PR. Adjunctive intrapleural tissue plasminogen activator administered via chest tubes placed with imaging guidance: effectiveness and risk for hemorrhage. *Radiology*. 2008;246(3):956-963.
37. Statler JD, Doherty RD, McLaughlin JJ, Gleason JD, McDermott MP. Tissue plasminogen activator in the percutaneous drainage of splenic abscess. *J Vasc Interv Radiol*. 2010;21(2):307-309.
38. Laborda A, De Gregorio MA, Miguelena JM, et al. Percutaneous treatment of intrabdominal abscess: urokinase versus saline serum in 100 cases using two surgical scoring systems in a randomized trial. *Eur Radiol*. 2009;19(7):1772-1779.
39. Cheng D, Nagata KT, Yoon HC. Randomized prospective comparison of alteplase versus saline solution for the percutaneous treatment of loculated abdominopelvic abscesses. *J Vasc Interv Radiol*. 2008;19(6):906-911.
40. Bae JH, Kim GC, Ryeom HK, Jang YJ. Percutaneous embolization of persistent biliary and enteric fistulas with Histoacryl. *J Vasc Interv Radiol*. 2011;22(6):879-883.
41. Demir E, Alan C, Kilciler M, Bedir S. Comparison of ethanol and sodium tetradecyl sulfate in the sclerotherapy of renal cyst. *J Endourol*. 2007;21(8):903-905.
42. Kok KY, Yapp SK. Laparoscopic drainage of postoperative complicated intra-abdominal abscesses. *Surg Laparosc Endosc Percutan Tech*. 10(5):311-3, 2000 Oct.
43. Kimura T, Shibata M, Ohhara M. Effective laparoscopic drainage for intra-abdominal

abscess not amenable to percutaneous approach: report of two cases. *Dis Colon Rectum*. 48(2):397-9, 2005 Feb.

44. Shuler FW, Newman CN, Angood PB, Tucker JG, Lucas GW. Nonoperative management for intra-abdominal abscesses. *Am Surg*. 62(3):218-22, 1996 Mar.
45. Holzheimer RG, Mannick JA. *Surgical Treatment: Evidence-Based and Problem-Oriented*. Munich: Zuckschwerdt; 2001.
46. Mueller PR, White EM, Glass-Royal M, et al. Infected abdominal tumors: percutaneous catheter drainage. *Radiology*. 1989;173(3):627-629.
47. Do H, Lambiase RE, Deyoe L, Cronan JJ, Dorfman GS. Percutaneous drainage of hepatic abscesses: comparison of results in abscesses with and without intrahepatic biliary communication. *AJR Am J Roentgenol*. 1991;157(6):1209-1212.
48. Schuster MR, Crummy AB, Wojtowycz MM, McDermott JC. Abdominal abscesses associated with enteric fistulas: percutaneous management. *J Vasc Interv Radiol*. 1992;3(2):359-363.
49. Lee WS, Choi ST, Kim KK. Splenic abscess: a single institution study and review of the literature. *Yonsei Med J*. 2011;52(2):288-292.
50. Takeshita N, Okumura Y, Sogami T, Deguchi E, Kizaki Z. Laparoscopic drainage of splenic abscess to avoid splenectomy. *Pediatr Int*. 60(9):898-900, 2018 Sep.
51. Chang KC, Chuah SK, Changchien CS, et al. Clinical characteristics and prognostic factors of splenic abscess: a review of 67 cases in a single medical center of Taiwan. *World J Gastroenterol*. 2006;12(3):460-464.
52. Tung CC, Chen FC, Lo CJ. Splenic abscess: an easily overlooked disease? *Am Surg*. 2006;72(4):322-325.
53. Choudhury SR, Debnath PR, Jain P, et al. Conservative management of isolated splenic abscess in children. *J Pediatr Surg*. 2010;45(2):372-375.
54. Ferraioli G, Brunetti E, Gulizia R, Mariani G, Marone P, Filice C. Management of splenic abscess: report on 16 cases from a single center. *Int J Infect Dis*. 13(4):524-30, 2009 Jul.
55. Lee MC, Lee CM. Splenic Abscess: An Uncommon Entity with Potentially Life-Threatening Evolution. *Can. j. infect. dis. med. microbiol.*. 2018;8610657, 2018.
56. Mohammed S, Kollu VS. Rare case of *Propionibacterium acnes*-related splenic abscess. *BMJ Case Rep*. 2018, 2018 Sep 21.
57. Alnasser SA, Mindru C, Preventza O, Rosengart T, Cornwell L. Successful Conservative Management of a Large Splenic Abscess Secondary to Infective Endocarditis. *Ann Thorac Surg*. 2018 Oct 13.
58. Bradley EL, 3rd. A clinically based classification system for acute pancreatitis. Summary of the International Symposium on Acute Pancreatitis, Atlanta, Ga, September 11 through 13, 1992. *Arch Surg*. 1993;128(5):586-590.
59. Foster BR, Jensen KK, Bakis G, Shaaban AM, Coakley FV. Revised Atlanta Classification for Acute Pancreatitis: A Pictorial Essay. [Review]. *Radiographics*. 36(3):675-87, 2016 May-Jun.
60. Tyberg A, Karia K, Gabr M, et al. Management of pancreatic fluid collections: A comprehensive review of the literature. [Review]. *World J Gastroenterol*. 22(7):2256-70,

2016 Feb 21.

- 61.** Varadarajulu S, Bang JY, Sutton BS, Trevino JM, Christein JD, Wilcox CM. Equal efficacy of endoscopic and surgical cystogastrostomy for pancreatic pseudocyst drainage in a randomized trial. *Gastroenterology*. 145(3):583-90.e1, 2013 Sep.
- 62.** Park JJ, Kim SS, Koo YS, et al. Definitive treatment of pancreatic abscess by endoscopic transmural drainage. *Gastrointest Endosc*. 55(2):256-62, 2002 Feb.
- 63.** Venu RP, Brown RD, Marrero JA, Pastika BJ, Frakes JT. Endoscopic transpapillary drainage of pancreatic abscess: technique and results. *Gastrointest Endosc*. 2000;51(4 Pt 1):391-395.
- 64.** Lang EK, Paolini RM, Pottmeyer A. The efficacy of palliative and definitive percutaneous versus surgical drainage of pancreatic abscesses and pseudocysts: a prospective study of 85 patients. *South Med J*. 1991;84(1):55-64.
- 65.** Akshintala VS, Saxena P, Zaheer A, et al. A comparative evaluation of outcomes of endoscopic versus percutaneous drainage for symptomatic pancreatic pseudocysts. *Gastrointest Endosc*. 79(6):921-8; quiz 983.e2, 983.e5, 2014 Jun.
- 66.** Mallick B, Dhaka N, Gupta P, et al. An audit of percutaneous drainage for acute necrotic collections and walled off necrosis in patients with acute pancreatitis. *Pancreatology*. 18(7):727-733, 2018 Oct.
- 67.** Mithofer K, Mueller PR, Warshaw AL. Interventional and surgical treatment of pancreatic abscess. *World J Surg*. 1997;21(2):162-168.
- 68.** Rotman N, Mathieu D, Anglade MC, Fagniez PL. Failure of percutaneous drainage of pancreatic abscesses complicating severe acute pancreatitis. *Surg Gynecol Obstet*. 1992;174(2):141-144.
- 69.** Steiner E, Mueller PR, Hahn PF, et al. Complicated pancreatic abscesses: problems in interventional management. *Radiology*. 1988;167(2):443-446.
- 70.** Giovannini M, Pesenti C, Rolland AL, Moutardier V, Delpero JR. Endoscopic ultrasound-guided drainage of pancreatic pseudocysts or pancreatic abscesses using a therapeutic echo endoscope. *Endoscopy*. 2001;33(6):473-477.
- 71.** Coelho RF, Schneider-Monteiro ED, Mesquita JL, Mazzucchi E, Marmo Lucon A, Srougi M. Renal and perinephric abscesses: analysis of 65 consecutive cases. *World J Surg*. 2007;31(2):431-436.
- 72.** Yen DH, Hu SC, Tsai J, et al. Renal abscess: early diagnosis and treatment. *Am J Emerg Med*. 1999;17(2):192-197.
- 73.** Breslin N, Wallace MB. Diagnosis and fine needle aspiration of pancreatic pseudocysts: the role of endoscopic ultrasound. [Review] [68 refs]. *Gastrointest Endosc Clin N Am*. 12(4):781-90, viii, 2002 Oct.
- 74.** But DY, Poley JW. To fine needle aspiration or not? An endosonographer's approach to pancreatic cystic lesions. [Review]. *Endosc. ultrasound*. 3(2):82-90, 2014 Apr.
- 75.** Wang IK, Chen YM, Chen YC, Fang JT, Hang CC. Successful treatment of renal abscess with percutaneous needle aspiration in a diabetic patient with end stage renal disease undergoing hemodialysis. *Ren Fail*. 25(4):653-7, 2003 Jul.
- 76.** Kuhajda I, Zarogoulidis K, Tsirgogianni K, et al. Lung abscess-etiology, diagnostic and

treatment options. [Review]. *Ann. transl. med.*. 3(13):183, 2015 Aug.

77. vanSonnenberg E, D'Agostino HB, Casola G, Wittich GR, Varney RR, Harker C. Lung abscess: CT-guided drainage. *Radiology*. 1991;178(2):347-351.
78. Yellin A, Yellin EO, Lieberman Y. Percutaneous tube drainage: the treatment of choice for refractory lung abscess. *Ann Thorac Surg*. 1985;39(3):266-270.
79. Kelogrigoris M, Tsagouli P, Stathopoulos K, Tsagaridou I, Thanos L. CT-guided percutaneous drainage of lung abscesses: review of 40 cases. *JBR-BTR*. 2011;94(4):191-195.
80. Wali SO.. An update on the drainage of pyogenic lung abscesses. *Ann Thorac Med*. 7(1):3-7, 2012 Jan.
81. Arellano RS, Gervais DA, Mueller PR. Computed tomography-guided drainage of mediastinal abscesses: clinical experience with 23 patients. *J Vasc Interv Radiol*. 2011;22(5):673-677.
82. Pages PB, Bernard A. [Lung abscess and necrotizing pneumonia: chest tube insertion or surgery?]. [Review] [French]. *Rev Pneumol Clin*. 68(2):84-90, 2012 Apr.
83. Moreira Jda S, Camargo Jde J, Felicetti JC, Goldenfun PR, Moreira AL, Porto Nda S. Lung abscess: analysis of 252 consecutive cases diagnosed between 1968 and 2004. *J Bras Pneumol*. 2006;32(2):136-143.
84. Pan H, He J, Shen J, Jiang L, Liang W, He J, A meta-analysis of video-assisted thoracoscopic decortication versus open thoracotomy decortication for patients with empyema. *J. thorac. dis.*. 9(7):2006-2014, 2017 Jul.
85. Shen KR, Bribriesco A, Crabtree T, et al. The American Association for Thoracic Surgery consensus guidelines for the management of empyema. [Review]. *J Thorac Cardiovasc Surg*. 153(6):e129-e146, 2017 06.
86. Janda S, Swiston J. Intrapleural fibrinolytic therapy for treatment of adult parapneumonic effusions and empyemas: a systematic review and meta-analysis. [Review]. *Chest*. 142(2):401-411, 2012 Aug.
87. Makdisi T, Makdisi G. Contemporary surgical management of thoracic empyema. *J. thorac. dis.*. 10(Suppl 26):S3069-S3070, 2018 Sep.
88. Ayyagari RR, Yeh C, Arici M, Mojibian H, Reiner E, Pollak JS. Image-Guided Transvesicular Drainage of Pelvic Fluid Collections: A Safe and Effective Alternative Approach. *J Vasc Interv Radiol*. 27(5):689-93, 2016 May.
89. Cahill AM, Baskin KM, Kaye RD, Fitz CR, Towbin RB. Transgluteal approach for draining pelvic fluid collections in pediatric patients. *Radiology*. 2005;234(3):893-898.
90. Harisinghani MG, Gervais DA, Maher MM, et al. Transgluteal approach for percutaneous drainage of deep pelvic abscesses: 154 cases. *Radiology*. 228(3):701-5, 2003 Sep.
91. Lee BC, McGahan JF, Bijan B. Single-step transvaginal aspiration and drainage for suspected pelvic abscesses refractory to antibiotic therapy. *J Ultrasound Med*. 2002;21(7):731-738.
92. Nelson AL, Sinow RM, Oliak D. Transrectal ultrasonographically guided drainage of gynecologic pelvic abscesses. *Am J Obstet Gynecol*. 2000;182(6):1382-1388.
93. Sperling DC, Needleman L, Eschelman DJ, Hovsepian DM, Lev-Toaff AS. Deep pelvic

abscesses: transperineal US-guided drainage. *Radiology*. 1998;208(1):111-115.

94. Thakral A, Sundareyan R, Kumar S, Arora D. Ultrasound guided transrectal catheter drainage of pelvic collections. *Trop Gastroenterol*. 36(1):64-7, 2015 Jan-Mar.
95. Jaffe TA, Nelson RC, Delong DM, Paulson EK. Practice patterns in percutaneous image-guided intraabdominal abscess drainage: survey of academic and private practice centers. *Radiology*. 2004;233(3):750-756.
96. Gjelland K, Granberg S, Kiserud T, Wentzel-Larsen T, Ekerhovd E. Pregnancies following ultrasound-guided drainage of tubo-ovarian abscess. *Fertil Steril*. 2012;98(1):136-140.
97. Rosen M, Breitkopf D, Waud K. Tubo-ovarian abscess management options for women who desire fertility. *Obstet Gynecol Surv*. 2009;64(10):681-689.
98. Chou YH, Tiu CM, Liu JY, et al. Prostatic abscess: transrectal color Doppler ultrasonic diagnosis and minimally invasive therapeutic management. *Ultrasound Med Biol*. 2004;30(6):719-724.
99. Lachiewicz MP, Nair N. Simple Technique for Transvaginal Aspiration of a Tubo-Ovarian Abscess. *Gynecol Obstet Invest*. 81(4):381-4, 2016.
100. Greenstein Y, Shah AJ, Vragovic O, et al. Tuboovarian abscess. Factors associated with operative intervention after failed antibiotic therapy. *J Reprod Med*. 58(3-4):101-6, 2013 Mar-Apr.
101. Levenson RB, Pearson KM, Saokar A, Lee SI, Mueller PR, Hahn PF. Image-guided drainage of tuboovarian abscesses of gastrointestinal or genitourinary origin: a retrospective analysis. *Journal of Vascular & Interventional Radiology*. 22(5):678-86, 2011 May. *J Vasc Interv Radiol*. 22(5):678-86, 2011 May.
102. Kairys N, Roepke C. Abscess, Tubo-Ovarian. *StatPearls*. Treasure Island (FL); 2018.
103. Garg CP, Vaidya BB, Chengalath MM. Efficacy of laparoscopy in complicated appendicitis. *Int J Surg*. 2009;7(3):250-252.
104. Mahadev S, Lee DS. Endoscopic Ultrasound-Guided Drainage of Pelvic Fluid Collections. [Review]. *Gastrointest Endosc Clin N Am*. 27(4):727-739, 2017 Oct.
105. Puri R, Eloubeidi MA, Sud R, Kumar M, Jain P. Endoscopic ultrasound-guided drainage of pelvic abscess without fluoroscopy guidance. *J Gastroenterol Hepatol*. 2010;25(8):1416-1419.
106. Mezhir JJ, Fong Y, Fleischer D, et al. Pyogenic abscess after hepatic artery embolization: a rare but potentially lethal complication. *J Vasc Interv Radiol*. 2011;22(2):177-182.
107. Law ST, Kong Li MK. Is there any difference in pyogenic liver abscess caused by *Streptococcus milleri* and *Klebsiella* spp?: retrospective analysis over a 10-year period in a regional hospital. *J Microbiol Immunol Infect*. 46(1):11-8, 2013 Feb.
108. Mavilia MG, Molina M, Wu GY. The Evolving Nature of Hepatic Abscess: A Review. [Review]. *J. clin. transl. hepatol.*. 4(2):158-68, 2016 Jun 28.
109. Zerem E, Hadzic A. Sonographically guided percutaneous catheter drainage versus needle aspiration in the management of pyogenic liver abscess. *AJR Am J Roentgenol*. 189(3):W138-42, 2007 Sep.
110. Hope WW, Vrochides DV, Newcomb WL, Mayo-Smith WW, Iannitti DA. Optimal treatment

of hepatic abscess. *Am Surg.* 74(2):178-82, 2008 Feb.

- 111.** Sharma BC, Garg V, Reddy R. Endoscopic management of liver abscess with biliary communication. *Dig Dis Sci.* 57(2):524-7, 2012 Feb.
- 112.** Sharma BC, Agarwal N, Garg S, Kumar R, Sarin SK. Endoscopic management of liver abscesses and cysts that communicate with intrahepatic bile ducts. *Endoscopy.* 38(3):249-53, 2006 Mar.
- 113.** Sugiyama M, Atomi Y. Pyogenic hepatic abscess with biliary communication. *Am J Surg.* 183(2):205-8, 2002 Feb.
- 114.** Qin SL, Wang AX, Sheng RY, Liu ZY. [Clinical analysis of 36 cases with amebic liver abscess]. *Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi.* 2000;18(6):356-358.
- 115.** Stain SC, Yellin AE, Donovan AJ, Brien HW. Pyogenic liver abscess. Modern treatment. *Arch Surg.* 1991;126(8):991-996.
- 116.** Pakala T, Molina M, Wu GY. Hepatic Echinococcal Cysts: A Review. [Review]. *J. clin. transl. hepatol.* 4(1):39-46, 2016 Mar 28.
- 117.** Smego RA Jr, Sebanego P. Treatment options for hepatic cystic echinococcosis. [Review] [88 refs]. *Int J Infect Dis.* 9(2):69-76, 2005 Mar.
- 118.** Rajesh R, Dalip DS, Anupam J, Jaisiram A. Effectiveness of puncture-aspiration-injection-reaspiration in the treatment of hepatic hydatid cysts. *Iran. j. radiol.* 10(2):68-73, 2013 Jun.
- 119.** Alkofer B, Dufay C, Parienti JJ, Lepennec V, Dargere S, Chiche L. Are pyogenic liver abscesses still a surgical concern? A Western experience. *HPB Surg.* 2012:316013, 2012.
- 120.** Pang TC, Fung T, Samra J, Hugh TJ, Smith RC. Pyogenic liver abscess: an audit of 10 years' experience. *World J Gastroenterol.* 17(12):1622-30, 2011 Mar 28.
- 121.** Tan YM, Chung AY, Chow PK, et al. An appraisal of surgical and percutaneous drainage for pyogenic liver abscesses larger than 5 cm. *Ann Surg.* 241(3):485-90, 2005 Mar.
- 122.** Hoffer FA, Emans J. Percutaneous drainage of subperiosteal abscess: a potential treatment for osteomyelitis. *Pediatr Radiol.* 26(12):879-81, 1996 Dec.
- 123.** Yeo A, Ramachandran M. Acute haematogenous osteomyelitis in children. [Review][Erratum appears in *BMJ.* 2014;348:1326]. *BMJ.* 348:g66, 2014 Jan 20.
- 124.** Weenders SG, Janssen NE, Landman GW, van den Berg FP. Subperiosteal abscess in a child. Trueta's osteomyelitis hypothesis undermined?. *Orthop Traumatol Surg Res.* 101(6):763-5, 2015 Oct.
- 125.** Sharma P, Sharma S, Gupta N, Kochar P, Kumar Y. Pott puffy tumor. *BAYLOR UNIV MED CENT PROC.* 30(2):179-181, 2017 Apr.
- 126.** Ghate S, Thabet AM, Gosey GM, Southern EP, Begue RE, King AG. Primary Osteomyelitis of the Clavicle in Children. *Orthopedics.* 39(4):e760-3, 2016 Jul 01.
- 127.** Lahav J, Handzel O, Gertler R, Yehuda M, Halperin D. Postauricular needle aspiration of subperiosteal abscess in acute mastoiditis. *Ann Otol Rhinol Laryngol.* 114(4):323-7, 2005 Apr.

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for

determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

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